

## IMAGE SENSING APPARATUS

### BACKGROUND OF THE INVENTION

#### Field of the Invention

5           The present invention relates to an image sensing apparatus having a noise reduction circuit and to a control method for such an image sensing apparatus. The invention also relates to a storage medium storing a program for sensing an image of an object, which  
10       program is executed by a CPU of the image sensing apparatus.

#### Related Background Art

          A conventional video camera has a noise reduction circuit for removing noises from a video signal. Noise  
15       reduction circuits as well as various other video signal processing circuits are now made of digital components along with the advent of digital video (DV) cassettes (SD format) and the like.

          A cyclic type using a field memory is generally  
20       used for a digital noise reduction circuit. As the price of a memory lowers nowadays, the digital noise reduction circuit is used also for general video cameras of home use.

          A cyclic type noise reduction circuit will be  
25       described which removes noises by using field images having correlation in time. As shown in Fig. 3, a cyclic noise reduction circuit has an input terminal

A signal Si input from the input terminal 51 is supplied to the adder 52 and subtractor 53. The subtractor 53 subtracts the signal Si from a signal Sf delayed by the field memory 55 to thereby detect a noise signal Sn1 between fields. The detected signal Sn1 is supplied to the limiter 56.

The adder 52 adds the signal  $S_i$  to the signal  $K \cdot S_{n2}$  to remove noise components from the signal  $S_i$ . A signal  $S_o$  output from the adder 52 is supplied to the field memory 55 and also output from the output terminal 57.

$$S_n = S_f - S_i \quad \dots (1)$$
$$\text{So} = \text{Si} + \text{K} \cdot \text{Sn}$$

$$\begin{aligned} &= S_i + K \cdot (S_f - S_i) \\ &= (1 - K) \cdot S_i + K \cdot S_f \quad \dots (2) \end{aligned}$$

As seen from the equation (2), the signal  $S_o$  having less noise components can be obtained as in the following. Since the signal  $S_i$  contains noise components and the signal  $S_f$  is a delayed signal of the signal  $S_o$  from which noise components are eliminated, the noise components become smaller the more the cyclic coefficient  $K$  is made as near as the value 1. If the cyclic coefficient  $K$  is set to 0, the signal  $S_i$  itself becomes the signal  $S_o$ .

The more effectively the noise components can be removed the more the cyclic coefficient  $K$  is made as near as the value 1. A video signal generated by a video camera is more likely to be affected by noises, because of high density mount of small components, high speed digitalization, high speed signal processing, and high speed component control. In order to avoid this, it is required to set the amount of noise reduction larger.

However, if the amount of noise reduction made larger, although the noise reduction effect is improved, influence of a preceding field upon a current field becomes large. Therefore, a latent image of a scene having a moving object becomes conspicuous.

This problem also occurs when a zoom operation is performed because the size of an object changes even if

the object does not move.

#### SUMMARY OF THE INVENTION

It is an object of the invention to provide an  
5 image sensing apparatus capable of sensing an image of  
an object always in good conditions by realizing an  
optimum noise reduction process even under various  
photographing conditions and even with various  
functions of the apparatus, a control method for the  
10 apparatus, and a storage medium storing a program for  
realizing such a function.

In order to achieve the above object of the  
invention, according to one aspect of the invention,  
there is provided an image sensing apparatus which  
15 comprises: noise reduction means for reducing noises of  
a sensed image by utilizing images having correlation  
in time; zoom control means for controlling a zoom  
magnification factor of the image sensing apparatus;  
judging means for judging whether the zoom control  
20 means is executing a zoom operation; and setting means  
for setting a control value for the noise reduction  
means in accordance with a judgement result by the  
judging means.

According to another aspect of the invention,  
25 there is provided an image sensing method which  
comprises the steps of: reducing noises of a sensed  
image by utilizing images having correlation in time;

controlling a zoom magnification factor of the image  
sensing apparatus; judging whether the zoom control  
step is executing a zoom operation; and setting a  
control value for the noise reduction step in  
5 accordance with a judgement result at the judging step.

According to another aspect of the invention,  
there is provided a storage medium storing a program  
for executing an image sensing method which comprises  
the steps of: reducing noises of a sensed image by  
10 utilizing images having correlation in time;  
controlling a zoom magnification factor of the image  
sensing apparatus; judging whether the zoom control  
step is executing a zoom operation; and setting a  
control value for the noise reduction step in  
15 accordance with a judgement result at the judging step.

Other objects and advantages of the present  
invention will become apparent from the following  
detailed description when read in conjunction with the  
accompanying drawings.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing the structure of  
an image sensing apparatus according to an embodiment.

Fig. 2 is a block diagram showing the structure of  
25 a system control unit.

Fig. 3 is a block diagram showing the structure of  
a cyclic type noise reduction circuit.

Fig. 4 is a flow chart illustrating the sequence of a noise reduction control process.

Fig. 5 is a flow chart illustrating the sequence of a noise reduction control process to be followed by the flow chart shown in Fig. 4.

Fig. 6 is a graph showing the relation between the brightness of an object and the value of a cyclic coefficient K in a zoom stop mode and in a zoom operation mode.

Fig. 7 is a graph showing the relation between the brightness of an object and the value of a cyclic coefficient K in the zoom stop mode and zoom operation mode, and at Steps 1 and 2.

Fig. 8 is a memory map of a ROM as a storage medium.

Fig. 9 is a block diagram showing the structure of an image sensing apparatus according to another embodiment.

Fig. 10 is a flow chart illustrating the sequence of a noise reduction control process.

Fig. 11 is a flow chart illustrating the sequence of a noise reduction control process to be followed by the flow chart shown in Fig. 10.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of an image sensing apparatus, a control method therefor and a storage

medium according to the invention will be described.

Fig. 1 is a block diagram showing the structure of an image sensing apparatus. In Fig. 1, reference numeral 11 represents a zoom lens for focussing the image of an object, reference numeral 12 represents a diaphragm for adjusting a light quantity, reference numeral 13 represents an image pickup device made of a CCD for converting input light into an electric signal, and reference numeral 14 represents a sample/hold AGC circuit for sample/hold and gain adjustment.

Reference numeral 15 represents an analog-digital (A/D) converter unit for A/D conversion, and reference numeral 16 represents a video signal processing unit for processing a signal and generating a video signal. Reference numeral 17 represents an electronic zoom unit having a field memory for image cut and paste, magnification, and interpolation. Reference numeral 18 represents a noise reduction (NR) unit having a field memory for reducing noises from a video signal.

Reference numeral 19 represents a lens position detection unit for detecting the position of the zoom lens, and reference numeral 20 represents a lens drive unit for driving the zoom lens.

Reference numeral 21 represents a system control unit for controlling the entirety of the image sensing apparatus. Fig. 2 is a block diagram showing the structure of the system control unit 21. The system

control unit 21 has a CPU 31, a ROM 32, a RAM 33 and an I/O interface which are well known in the art. ROM 32 stores programs and table values to be described later, the programs being executed by CPU 31.

5           Reference numeral 22 represents a zoom operation key unit having keys for zoom operations. Reference numeral 23 represents a wide key for moving the zoom lens in a wide (wide = image reduction) direction, and reference numeral 24 represents a telephoto key for  
10           moving the zoom lens in a telephoto (telephoto = image magnification) direction. For example, the wide key 23 and telephoto key 24 are keys of a see-saw type moving together. Each key outputs a signal representative of a depression pressure to the system control unit 21.  
15           The noise reduction (NR) unit 18 is made of a conventional cyclic type noise reduction circuit. Fig. 3 shows the structure of a cyclic type noise reduction circuit. The noise reduction circuit has the input terminal 51, adder 52, subtractor 53, multiplier 54,  
20           field memory 55, limiter 56 and output terminal 57. The operation of the cyclic type noise reduction circuit has been described in connection with the related art.

          Light from an object received by the zoom lens 11  
25           is adjusted in amount by the diaphragm 12 and focussed on the surface of the image pickup device. After the light is converted into an electric signal by the image



pickup device 13, the electric signal is supplied to the sample/hold AGC unit 14, A/D converted by the A/D converter unit 15, and input to the video signal processing unit 16.

5           The video signal processing unit 16 performs aperture correction, gamma correction, white balance correction and the like for each brightness and color component of an input signal, to thereby generate a video signal which is output to the electronic zoom  
10           unit 17. The electronic zoom unit 17 performs image cut and paste, magnification, and interpolation by using the field memory so that an output image has a magnification factor relative to an input image, the magnification factor being determined by a control  
15           signal supplied from the system control unit 21.

          The noise reduction unit 18 reduces noises in the video signal in response to a control signal supplied from the system control unit 21. The noise reduced video signal is output to a recorder or the like  
20           connected to the noise reduction unit 18.

          The system control unit 21 controls each component of the image sensing apparatus. As the wide key 23 or telephoto key 24 of the zoom operation key unit 22 is depressed, the system control unit 21 also controls the  
25           lens drive unit 20 or electronic zoom unit 17 to move the zoom lens in the wide or telephoto direction.

          The system control unit 21 judges, from a lens

position detection signal supplied from the lens  
position detection unit 19, at which position (zoom  
magnification factor) including the telephoto end  
(furthest telephoto end) and wide end (widest angle  
5 end), the zoom lens is. A function of magnifying an  
image picked up with a lens optical system is called an  
optical zoom, whereas a function of vertically and  
horizontally magnifying an image by an electronic  
signal process without using the lens optical system is  
10 called an electronic zoom.

The system control unit 21 generally performs the  
optical zoom by driving the zoom lens 11 in the range  
of a magnification factor which can be set with the  
optical zoom. After the zoom lens 11 arrives at the  
15 telephoto end, the image is electronically magnified by  
the electronic zoom under the control of the electronic  
zoom unit 17. In this embodiment, the maximum  
magnification factor of the optical zoom is set to 12  
times and the maximum magnification factor of the  
20 electronic zoom is set to 4 times, so that the zoom  
operation with the high magnification factor of 48  
times is possible.

The system control unit 21 outputs a noise  
reduction control signal to the noise reduction unit  
25 18, the control signal being set differently in case of  
that the optical and electronic zooms are stopped and  
in a case of that the zooms are operated, so that the

amount of noise reduction can be changed. The noise reduction control signal corresponds to the cyclic coefficient K.

5 This control signal is also changed with the brightness of an object. The S/N of a video signal lowers as the brightness of an object becomes dark. In order to compensate for this, the control signal is changed to make the noise reduction amount larger.

10 In order to maintain the level of a video signal at a predetermined value even if the amount of input light from an object changes, the system control unit 21 controls the diaphragm 12, sample/hold AGC unit 14, electronic shutter (not shown in Fig. 1) and the like by judging the brightness of the object collectively  
15 from a diaphragm value, an AGC gain, an electronic shutter speed and the like (hereinafter called exposure control data) used for exposure control.

Next, the optical zoom, electronic zoom and noise reduction controls by the system control unit 21 will  
20 be described. Figs. 4 and 5 are flow charts illustrating the noise reduction control process. The program for this process is stored in ROM 32 of the system control unit 21 and executed by CPU 31.

The system control unit 21 judges whether the  
25 telephoto key 24 is depressed (Step S201). If depressed, it is checked whether the position of the zoom lens is at the telephoto end (optical zoom

magnification factor of 12 times) (Step S203). If the position of the zoom lens 11 is the telephoto end, the zoom lens 11 is fixed to the telephoto end (Step S204).

It is then checked whether the electronic zoom magnification factor of the electronic zoom unit 17 is the maximum of 4 times. If 4 times, the electronic zoom magnification factor is fixed to 4 times (Step S206). If not the maximum of 4 times, the electronic zoom unit 17 is controlled to increase the magnification factor to a predetermined value (Step S207). In this embodiment, although the maximum magnification factor of the optical zoom is set to 12 times and that of the electronic zoom is set to 4 times, other magnification factors may also be set.

If the position of the zoom lens 11 is not the telephoto end at Step S203, the lens drive unit 20 is controlled to move the zoom lens 11 in the telephoto direction and increase the magnification factor to a predetermined value (Step S208). The magnification factor of the electronic zoom is fixed to an equal magnification (Step S209).

If the telephoto key 201 is not depressed at Step S201, it is checked whether the wide key 23 is depressed (Step S202). If depressed, it is checked whether the electronic zoom magnification factor of the electronic zoom unit 17 is the minimum of the equal magnification (Step S212).

If the electronic magnification factor is the minimum of the equal magnification, the electronic zoom unit 17 is controlled to fix the electronic zoom magnification factor to the equal magnification. It is then checked whether the position of the zoom lens 11 is the wide end (optical zoom magnification factor of equal magnification) (Step S214). If the position is the wide end, the zoom lens 11 is fixed to the wide end (Step S215).

If the position of the zoom lens 11 is not the wide end, the lens drive unit 20 is controlled to move the zoom lens 11 in the wide direction and reduce the magnification factor to a predetermined value (Step S216).

If the electronic zoom magnification factor is not the equal magnification at Step S212, the electronic zoom unit 17 is controlled to reduce the magnification factor of the electronic zoom to a predetermined value (Step S217). The zoom lens 11 is fixed to the telephoto end (Step S218).

If the wide key 23 is not depressed at Step S202, the electronic zoom unit 17 is controlled to fix the electronic zoom magnification factor without being changed (Step S210). In order to fix the electronic zoom magnification factor of the zoom lens 11, the lens drive unit 20 is controlled to stop the zoom lens 11 (Step S211).

Under the conditions that the electronic zoom unit 17 and zoom lens 11 are stopped, the noise reduction unit 18 is controlled to set the noise reduction control mode to a zoom stop mode (Step S219).

5 Under the conditions that either the electronic zoom unit 17 or the zoom lens 11 is operated, the noise reduction unit 18 is controlled to set the noise reduction control mode to a zoom operation mode (Step S220). Thereafter, the system control unit 21  
10 temporarily terminates the process, and after it controls each component of the image sensing apparatus, it again repeats the process from Step S201 to Step S220.

As described above, according to this embodiment,  
15 it is judged whether the zoom variable magnification operation is being executed. In accordance with this judgement, the cyclic coefficient of the noise reduction is changed. This method is more effective than the case wherein a motion vector of an image under  
20 the variable magnification operation is detected and in accordance with the detection result, the noise reduction is changed. The reason for this is as follows. Since the mechanism for detecting a motion vector of an image is a feedback loop, there is a delay  
25 in changing the noise reduction. Also, the motion vector of an image under the variable magnification operation diverges so that the motion vector of the

whole image converges to zero. A proper detection is therefore impossible.

Fig. 6 is a graph showing the relation between the cyclic coefficient K and the brightness of an object in the zoom stop mode and in the zoom operation mode.

Steps S219 and S220 are executed in accordance with the graph shown in Fig. 6. The ordinate represents the cyclic coefficient K of the noise reduction. As the

cyclic coefficient K changes from "0" to nearer to "1", the noise reduction amount becomes larger and the latent image becomes more conspicuous. As shown in

Fig. 6, the cyclic coefficient K of the noise reduction is set smaller during the zoom operation (zoom operation mode) than during the zoom stop mode to lower

the noise reduction amount. The latent image phenomenon can therefore be suppressed. The abscissa represents the brightness of an object which is judged from the exposure control data. The brightness of an

object is divided into areas A, B, C and D from the brighter side in accordance with a predetermined

reference value.

In the zoom stop mode, the cyclic coefficient K of the noise reduction is "31/32" in the brightest area A of an object. As the brightness of the object changes to the area B, the cyclic coefficient is changed to "63/64". As the area changes to the areas C and D, the value is changed to "127/128" and "255/256"

In the zoom operation mode, the cyclic coefficient  
5 K of the noise reduction is "3/4" in the area A. As  
the area changes to the areas B, C and D, the  
coefficient changes to the values "7/8", "15/16" and  
"31/32" respectively, similar to the zoom stop mode.

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the noise reduction can take the value only on the zoom



stop mode control line and the zoom operation mode control line shown in Fig. 6, in the zoom stop mode, the zoom operation mode, a transfer from the zoom stop mode to zoom operation mode and a transfer from the zoom operation mode to zoom stop mode. If there is a large difference in the noise reduction amount between the noise reduction control value in the zoom stop mode and the noise reduction control value in the zoom operation mode, intermediate modes Step 1 and Step 2 may be provided between the zoom stop and operation modes as shown in Fig. 7 to use the cyclic coefficients K at Steps 1 and 2 when the mode is transferred. In this manner, it is possible to suppress the influence, upon images, of switching between the noise reduction control value during the mode transfer. Fig. 7 is a graph showing the relation between the object brightness and the cyclic coefficient K in the zoom stop and operation modes and at Steps 1 and 2.

In the optical zoom or electronic zoom operation of the embodiment, a change in the magnification factor per unit time may be increased or decreased to stepwise change the zoom speed in accordance with the depression force of the wide key or telephoto key. For example, if the zoom speed is increased more as the key is depressed more strongly, the control value K of the noise reduction is gradually lowered in proportion to the zoom speed to thereby suppress the latent image

phenomenon. For example, if the zoom speed has three levels, low speed, middle speed and high speed, Step 1 shown in Fig. 7 is used at the low speed, Step 2 is used at the middle speed, and the zoom operation mode control line is used at the high speed to thereby lower the value K in proportion to the zoom speed. In this manner, influence of the zoom speed upon images can be suppressed by switching the noise reduction control value.

Also in this embodiment, the zoom lens 11 for optically changing the size of a picked-up image and the electronic zoom unit 17 for changing the size of a picked-up image through electronic signal processing are used in combination. The embodiment is applicable also to the case wherein either the zoom lens 11 or the electronic zoom unit 17 is used.

In this embodiment, as shown in Fig. 1, a video signal is processed by the electronic zoom unit 17 for the electronic zoom of an image, and thereafter, the noise reduction unit 18 performs a noise reduction operation. In another embodiment of the invention, as shown in Fig. 9, an electronic zoom unit 17 may be provided at the succeeding stage of a noise reduction unit 18.

The flow charts illustrating the operation of an image sensing apparatus having the structure shown in Fig. 9 are shown in Figs. 10 and 11. In the flow

charts shown in Figs. 10 and 11, Steps having reference numerals identical to those shown in Figs. 4 and 5 execute the operations similar to those described with reference to Figs. 4 and 5, and the descriptions thereof are omitted.

At Step S207 shown in Fig. 10, if an image magnification operation is being executed by the electronic zoom, the flow advances to Step S219 whereat the noise reduction is switched to the zoom stop mode to increase the noise reduction cyclic coefficient K similar to the case of that the zoom operation is stopped.

At Step S217 shown in Fig. 11, if an image reduction operation is being executed by the electronic zoom, the zoom lens is stopped at the telephoto end (Step S218) to thereafter follow Step S219 whereat the noise reduction is switched to the zoom stop mode to increase the noise reduction cyclic coefficient K similar to the case of that the zoom operation is stopped.

In this embodiment, while the electronic zoom is executed, even if the cyclic coefficient K of the noise reduction is made large similar to the coefficient K of the zoom stop mode, the latent image phenomenon will not occur while the electronic zoom is executed and noises can be reduced, because the electronic zoom is executed after the noise reduction of a video signal.

The invention is also applicable to a system constituted of a plurality of apparatus or to a single apparatus. It is obvious that the object of the invention can be achieved by supplying a system or  
5 apparatus with a software program. In this case, the system or apparatus reads the program stored in a storage medium to realize the functions and effects of the invention.

Fig. 8 is a memory map of ROM 32 as such a storage  
10 medium. ROM 32 stores a noise reduction control program module realizing the process of the flow charts shown in Figs. 4 and 5, the table values of the cyclic coefficient K shown in the graph of Fig. 6, and the  
15 table values of the cyclic coefficient K shown in the graph of Fig. 7.

The storage medium storing the program module is not limited only to ROM, but other media may be used such as a floppy disk, a hard disk, an optical disk, a magnetooptical disk, a CD-ROM, a CD-R, a DVD, a  
20 magnetic tape, and a nonvolatile memory card.

The scope of the invention also contains the case wherein the functions of each embodiment can be realized by writing the program codes read from the storage medium into a memory of a function expansion  
25 board inserted into a computer or of a function expansion unit connected to the computer, and thereafter by executing a portion or the whole of

actual processes by a CPU of the function expansion board or function expansion unit.

As described so far, according to the image sensing apparatus of the embodiments, the control value of the noise reduction unit is set to a value providing a smaller noise reduction amount in the variable magnification operation mode than in the variable magnification stop mode. Therefore, irrespective of the telephoto or wide zoom operation direction, the noise reduction amount is set smaller in the zoom operation mode than in the zoom stop mode so that the latent image phenomenon to be caused by a change in the size of an object image during the zoom operation mode can be suppressed.

According to the image sensing apparatus of the embodiments, the control value of the noise reduction is changed with a control value for the exposure adjustment which maintains the level of a generated video signal constant irrespective of the amount of light from an object. It is therefore possible to increase the noise reduction amount so as to compensate for the S/N of a video signal to be degraded by the dark brightness of an object. The invention is therefore applicable to provide larger noise reduction amount of an object at a low brightness more than that of an object at a sufficient brightness.

Many widely different embodiments of the present

invention may be constructed without departing from the spirit and scope of the present invention. It should be understood that the present invention is not limited to the specific embodiments described in the specification, except as defined in the appended claims.

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